ogists as "perfect", "acceptable" or "poor". *Results:* In heparin adjustment study, system's suggestions were rated as perfect in 21 of 32 (65%) and as acceptable in 8 of 32 (25%). The rest 3 cases were rated as poor initially, after we modified the knowledge base, 1 of those 3 were rated as perfect and the remaining 2 as acceptable. In bleeding management study, 5 of 6 (83%) cases were rated as perfect and 1 of 6 as acceptable, none was rated as poor. *Conclusion:* This knowledge based computer expert system, simulating human decision making in the management of post-PTCA patients, provided promising results and is clinically applicable.

1022-52 Model-Based Image Processing of Transmitral Doppler E-waves Can Differentiate Hypertensives from Normals

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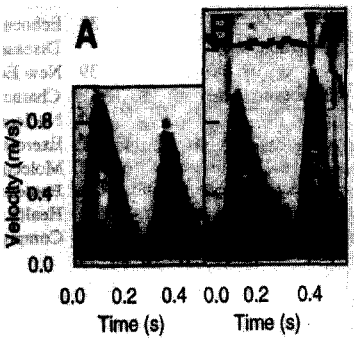
The Doppler velocity profiles (DVP) of 8 hypertensives (HTN) with LVH and 8 age matched normal controls (NLS) were compared using conventional (CVN) vs model-based image processing (MBIP) derived indexes to determine the indexes ability to differentiate among groups. (See Fig with DVP of NL (A), and HTN (B) subject, with MBIP contour superimposed). The MBIP method relies solely on digitally acquired DVP video images for input, which are analyzed via an automated method using the parametrized diastolic filling (PDF) formalism. This eliminates the need for hand digitizing of the contour, its determination by eye or the placement of cursors by hand. It therefore negates any observer dependent effects in index determination. MBIP indexes were: potential energy ($1/2kx_0^2$), spring constant k, initial spring displacement x_0, and damping constant c. Intergroup comparison using unpaired t-test was performed. Not significant ($p > 0.05$) CVN indexes were: E/A, Peak E, $\int E$, $\int E+\int A$, $\int E/\int E+\int A$ and E-wave deceleration time. Comparison of *MBIP* vs CVN indexes computed from analysis using *only* E-wave data yielded results in Table below.



	HTN	NLS	p
$1/2kx_0^2$	1.98 ± 0.8	0.98 ± 0.52	0.0130
E-wave c	33.8 ± 9.9	18.9 ± 5.8	0.0026
E acc. time	0.057 ± 0.02	0.084 ± 0.02	0.0168

We conclude, DVP analysis using an automated, MBIP method yields novel, model-based indexes that differentiate between E-waves of hypertensives and normals at least as well or better than conventional Doppler indices of diastolic function in current use. This automated method is easily applied to conventional video images and is suitable for observer independent DVP characterization.

1022-53 Improving Impedance Cardiographic Lead Configuration by Using a Detailed 3D Finite Element Model of Thorax

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Impedance cardiography (ICG) has not achieved wide clinical acceptance in the measurement of cardiac output because its theoretical basis and results obtained remain controversial. We have developed a detailed, physiologically accurate 3D computer thorax model using the U.S. National Library of Medicine's Visible Human Man digital anatomy data. By applying the finite element method, we have studied the theoretical properties of traditional, empirically developed ICG electrode configurations. The model consists of 30 distinct tissue types and contains about 500 000 nonuniform elements. Volume conductor analysis including reciprocal energization of leads and lead field analysis was used to determine the sensitivity of conventional and modified spot electrode configurations to regional conductivity changes. We also investigated the possibility of improving ICG measurement using 12-lead ECG electrode locations and concentrating the measurement sensitivity in certain regions of the thorax to provide accurate and well defined measurements. Conventional ICG was shown to be highly insensitive to conductivity changes in the region of the heart and aorta. More than 75% of the sensitivity was concentrated in the skeletal muscle and less than 5% in the blood masses and heart muscle. Replacing band electrodes with spot electrodes altered the measurement sensitivity remarkably. Preliminary results demonstrated that it is possible to define significantly more selective electrode montages which can provide information about physiological factors affecting cardiac output. For example, using four of the 12-lead ECG electrode locations sensitivity to conductivity changes in the right ventricle was increased 10-fold.

1022-54 Digital Acoustic Analysis: A Cost-Effective Alternative to Echocardiography for Evaluating Systolic Murmurs

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The differentiation of pathologic from innocent systolic murmurs is a frequent indication for echocardiography, and occasionally, cardiology consultation. Economic initiatives have stimulated technologic developments to screen such patients in a more cost-effective manner. We performed the first adult evaluation of a new disposable sensor combined with real-time spectral analysis and determined the accuracy of this system for detecting pathology. Acoustic spectra were measured by a blinded investigator in 57 randomly selected patients, 29 women, and 28 man, mean age 50 ± 20 years, who were referred for transthoracic echocardiography (TTE) to evaluate systolic murmurs; a subset of 43 patients underwent blinded cardiac physical examinations (PE) by cardiology staff or senior fellows.

Results: Cardiac pathology was detected in 32 subjects (56%) by TTE, in 31 subjects (54%) by spectral analysis, and in 20 subjects (47%) by PE. Spectral analysis exhibited a sensitivity of 97%, a specificity of 52%, a positive predictive value (PPV) of 72%, and a negative predictive value of 93%. PE yielded a sensitivity of 87%, a specificity of 70%, a PPV of 77%, and a NPV of 82%. The single pathologic murmur missed by spectral analysis was mild aortic stenosis with a peak instantaneous gradient of 30 mmHg. Mean examination time for spectral analysis was 15 minutes.

Conclusion: Spectral analysis using a disposable sensor technique is a highly sensitive and moderately specific method for detecting valvular pathology in subjects with systolic murmurs referred for TTE. This system given a cost approximately 10% that of TTE, may have future utility as a screening test.

1022-55 ELECTRA: A MATLAB®-based Electrogram Analysis Toolbox

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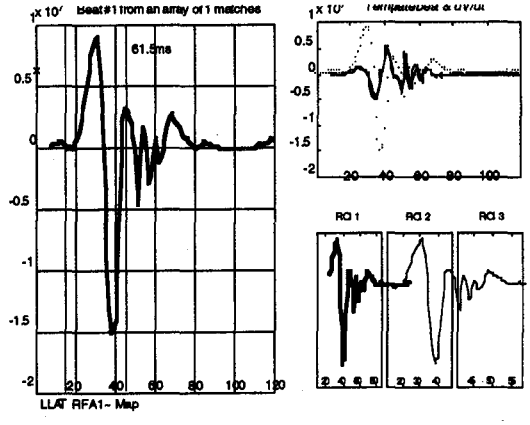
We developed a software environment for analysis of electrogram data obtained from a variety of systems that are used clinically in the Electrophysiology Laboratory.

The Electra Toolbox is placed in the public domain and runs under MATLAB®, a commercially available numerical computation software package that has been ported to most operating systems.



TUESDAY POSTER

Multi-channel recordings can be analyzed in both the time- and frequency domains. Using a correlation waveform algorithm, individual beats can be detected and averaged, in preparation for spectral or wavelet analysis. The package provides the ability to specify regions of interest within the recording, to examine features of the electrograms.

Its application in the clinical setting may provide insight in arrhythmia mechanisms and can serve as a versatile educational or diagnostic tool.

1022-56 Software for Receiver Operating Characteristic (ROC) Analysis and Evalution of Sensitivity and Specificity

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Linear regression and analysis of variance are the two common statistical methods used in cardiovascular research as well as many other areas. Medical decisions, however, often involve a nonlinear process of thresholding or grading and thus require a different type of analysis approach. The purpose of this study is to develop a computer program for analyzing outcomes of clinical decisions in terms of sensitivity and specificity. The program is also capable of estimating the receiver operating characteristic (ROC) curves which can be used to assess performance in a multiple-grading study or to determine the optimal threshold for making a medical decision. In the case where a decision is based on thresholding, the outcome of the decision is a true positive, a true negative, a false positive, or a false negative. If sufficient data are available, sensitivity (or true positive rate) can be estimated by 1 – FN/AP, where FN is the number of false negatives and AP is the number of actual positives; specificity (or true negative rate) can be estimated by 1 f- FP/AN, where FP is the number of false positives and AN is the number of actual negatives. A ROC curve is obtained by plotting sensitivity vs. (1 – specificity) as the threshold is systematically varied. The theoretically optimal operating point on the ROC plane is the upper-left corner that corresponds to 100% sensitivity and 100% specificity. However, real-world data are usually insufficient to produce a complete ROC curve. By assuming the underlying probability distribution, e.g. the normal distribution, a ROC curve can be estimated from a relatively small set of data. The program also provides the goodness-of-fit test on the assumption of probability distribution. The software has been developed for the Macintosh computers. The software receives a text file as input which can be generated by a standard spreadsheet program. A tutorial has also been developed to demonstrate the use of this software based on examples of diagnosis and management for cardiac patients. The software should be useful to perform sensitivity-specificity and ROC analyses in clinical studies involving threshold-based decisions.

1022-57 Evaluation of Signal-Averaged Cardiokymography for the Detection of Ischemic Ventricular Dysfunction

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Cardiokymography (CKG) is a non invasive diagnostic method for the detection of left-ventricular wall-motion abnormalities (WMA). A recently developed signal-averaged CKG system allows recording of reproducible precordial CKG curves and facilitates interpretation by a pseudo three-dimensional display. We investigated 70 patients (PTS) with suspected coronary artery disease (CAD) during dobutamine stress echocardiography (SE). Stress induced WMA should result in changes of CKG curve morphology. CKG curves were recorded for 1–2 min at rest and at maximal stress. All patients underwent subsequent coronary arteriography. CKG curves were classified into three different types: type 1 = normal (systolic *inward* movement), type 2 = pathologic (meso-systolic *outward* movement), type 3 = pathologic (pan-systolic *outward* movement). A positive CKG-test (indicating myocardial ischemia) was defined as follows: 1) a change from a type 1-CKG at rest to a type 2 or type 3-CKG, 2) a change from a type 2-CKG at rest to a type 3-CKG during pharmacological stress testing. *Results:* The CKG-test was positive in 28/38 PTS with induced echocardiographic WMA (sensitivity 74%), 29/32 PTS without dobutamine-induced WMA (negative SE) had no change in prior CKG-type (specificity 91%). Sensitivity of the SE-test for the detection of significant CAD (≥ 50% stenosis) was 77%, specificity was 91%, respectively. The presence or absence of WMA at rest did not result in a decreased sensitivity of the CKG test (73% vs. 75%, $p < 0.05$), but small WMA of less than 3 echocardiographic segments were frequently not detected by CKG. *Conclusions:* Signal-averaged CKG is a sensitive method for the detection of PTS with WMA due to myocardial ischemia. Therefore, signal averaged CKG may serve as additional diagnostic tool in the evaluation of PTS with suspected CAD.

1023 Cardiac MRI: Arterial Imaging, Flow, and Myocardial Stress

Tuesday, March 18, 1997, 3:00 p.m.–5:00 p.m.
Anaheim Convention Center, Hall E
Presentation Hour: 3:00 p.m.–4:00 p.m.

1023-102 Coronary Blood Flow Quantification Using Magnetic Resonance Phase Mapping: Comparison With Intracoronary Doppler Flow Measurement

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Beside the angiographic display of coronary arteries blood flow quantification provides essential information on the hemodynamic relevance of coronary artery stenoses. Recently, magnetic resonance (MR) flow quantification has been available. This method represents an attractive non-invasive alternative to intracoronary Doppler flow measurements. The aim of this study was to determine the coronary blood flow using MR phase mapping and to compare the results with intracoronary Doppler flow measurements.

The coronary arteries of 20 patients with coronary artery disease (CAD) were investigated. Blood flow measurements were performed in the proximal segments of the left anterior descending (LAD) and the right coronary artery (RCA). MR images were obtained on a 1.5 T scanner (VISION, Siemens) using a circular polarized body array coil with a 25 mT/m gradient system. A segmented flow encoded FLASH (fast low angle shot) sequence was applied. Temporal resolution was between 50 and 110 ms. The flow measurement was performed in 13 patients over the whole cardiac cycle allowing to calculate peak flow velocity, mean flow velocity and volume flow. The data of 7 patients were compared with intracoronary Doppler flow measurements.

In the LAD, peak flow and mean flow velocities were amounted to 19 ± 5 cm/s and 13 ± 6 cm/s. respectively. In the RCA, 8 ± 2 cm/s and 6 ± 1 cm/s were measured. The calculated volume flow was 49 ± 19 ml/min in the LAD and 21 ± 10 ml/min in the RCA. A close correlation was found between the data of MR phase mapping and intracoronary Doppler flow measurements with $r = 0.87$ for the peak velocity and $r = 0.78$ for the mean velocity. However, MR data showed significantly lower values than the invasively obtained data ($p < 0.01$).

Magnetic resonance phase mapping is a feasible method to perform blood flow quantification in coronary arteries. Higher spatial and temporal resolution studies would permit improved accuracy and reproducibility. Factors such as overall myocardial motion and partial volume effects have to be taken into account.

1023-103 Recruitable Myocardial Deformation During Dobutamine Stimulation by Magnetic Resonance Imaging With Tagging

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Regional recruitable function in response to dobutamine stimulation is frequently used in the detection of viable/ischemic myocardium. To determine the detailed magnitude and distribution of recruitable myocardial deformation in the normal human heart we studied 9 normal volunteers by MRI with myocardial tagging during control and dobutamine at 5 (D5) and 20 μg/kg/min infusion (D20). 4 short-axis slices at 6–7 phases encompassing the entire systolic interval were analyzed. The minimal principal strain, maximal shortening (MS) and its angular orientation away from the circumferential direction were measured transmurally in the entire left ventricle. MS at mid-wall augmented from 0.18 ± 0.02 (control) to 0.20 ± 0.02 (10.9% increase) at D5 and to 0.24 ± 0.03 (29.3% total increase) at D20, (ANOVA $p < 0.001$). MS orientation shifted further from circumferential direction during D20 vs. control (18 ± 3º vs. 14 ± 3º at mid-wall, $p < 0.01$). During control, MS and MS direction were greater in endocardium (0.22 ± 0.03, 21 ± 6º) than in epicardium (0.15 ± 0.02, 15 ± 3º, $p < 0.05$ for both), but recruitable MS increased similarly in both layers (30.2% and 28.1% at D20, NS). MS was greater in LV free wall (0.21 ± 0.01) than in septum (0.17 ± 0.02, $p < 0.04$) but recruitable MS (% Δ MS increase) at D20 was greater in septum than in free wall (31.0% vs 26.7%, $p < 0.05$). In conclusion, recruitable myocardial function increases at progressive levels of dobutamine and alters normal myocardial contraction orientation, such effect is uniform transmurally and greater at the level of the LV septum.